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AQUATIC MONITORING OF THE 1977 SPRUCE BUDWORM
SEVIN-4-OIL AERIAL SPRAY PROJECT
IN WASHINGTON STATE

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INTRODUCTION

During the summer of 1977 the USDA Forest Service treated some 357,000 acres of forest lands in the Okanogan and Wenatchee National Forests with the insecticide, Sevin-4-Oil, to control an outbreak of the western spruce budworm, Choristoneura occidentalis (Clem.). The spruce budworm is a caterpillar that feeds upon the needles of spruce and fir trees.

The Washington Department of Ecology was contracted to monitor impacts of the spray project on the aquatic environment. The results of this effort are presented in this report.

BACKGROUND

The spray project was administered by the USDA Forest Service in cooperation with the Washington Department of Natural Resources. Three major blocks of forest lands were treated during June, July and August:

- (1) Okanogan Unit - 127,000 acres of the Okanogan National Forest near Twisp, Okanogan County.
- (2) Wenatchee Unit - 134,000 acres of the Wenatchee National Forest near Wenatchee and Leavenworth, Chelan County.
- (3) Ellensburg Unit - 97,000 acres of the Wenatchee National Forest near Ellensburg, Kittitas County.

The Sevin was mixed with diesel oil at a rate of 3 pounds active ingredient (AI) per 1 gallon carrier. Helicopters applied the chemical at about 1 pound (AI) per acre. A buffer strip of at least 50 feet was left along all major streams and tributaries to minimize adverse impacts on water quality and aquatic life.

METHODS

Six streams were monitored during the study. These included Falls and Bear creeks in the Okanogan Unit; Beaver, Tommy and Squilchuck creeks in the Wenatchee Unit; and Naneum Creek in the Ellensburg Unit (Figures 1 and 2).

Four sampling stations were established on each stream:

Station 1 was located within the spray area near the lower spray boundary, where the maximum adverse environmental impacts would be expected to occur.

Stations 2 and 3 were spaced at about 1 1/2 mile intervals below station 1, in the dilution zone below the spray area.

Station 4 was a control located on a nearby creek of size and characteristics similar to the study stream.

Sampling equipment was the same as used during the DOE 1976 Spruce Budworm Aerial Spray Monitoring Project (Tracy, et al., 1976).

Each stream was sampled 4 times. A prespray sampling run was conducted one week prior to application. Sprayday monitoring was conducted followed by a 2-day postspray run, then a final run was made about one month after sprayday.

The study design at stations 1 and 3 on each program stream included five important aspects:

- (1) Stream surveys
- (2) Drift insect sampling
- (3) Quantitative benthic sampling
- (4) In-situ bioassays
- (5) Pesticide residue sampling

Stream surveys were conducted to identify conditions that could influence the monitoring study. General characteristics were noted such as stream size, flow regime and amount of forest canopy covering the watercourse.

The amount of insects adrift in a stream has been shown to increase significantly when a toxic material is introduced. To detect changes in insect drift, a 12" x 18" fyke net was set in the stream during sprayday and "fished" 10 minutes per hour commencing at 0400 hours and terminating at about 1600. The hourly drift samples were fixed in 70% alcohol, then the captured insects were counted by Order.

Quantitative benthic samples provided a measure of the diversity and abundance of benthic insect communities in the program streams. Twelve stones of similar shape and size were collected from riffles before and after application. Insects were removed from each stone and counted by Order, then the number of organisms per square foot surface area was calculated. The pre- and postspray counts provided before and after comparisons.

Fish and insect live boxes were placed in each program stream before sprayday to obtain a live/dead ratio following application. Hatchery-reared yearling spring chinook salmon, 4 inches in length, were used in all streams except Naneum Creek where 2 to 4-inch rainbow trout were used. Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) were used at 20 organisms per livebox. The livebox fish and insects were placed in the study streams about 2 days before spraying and counted 24 hours after application.

Samples of stream water, benthic insects, bottom sediment and livebox fish were collected for Sevin residue analysis. During sprayday, stream water samples were collected hourly from 0400 until spraying commenced, at 1/2 hour intervals for the next 4 hours, hourly for 4 more hours, then every 2 hours until insect drift counts dropped to prespray levels.

Sampling at stations 2 and 4 was limited to the stream surveys, fish and benthic insect in-situ bioassays, and residue samples.

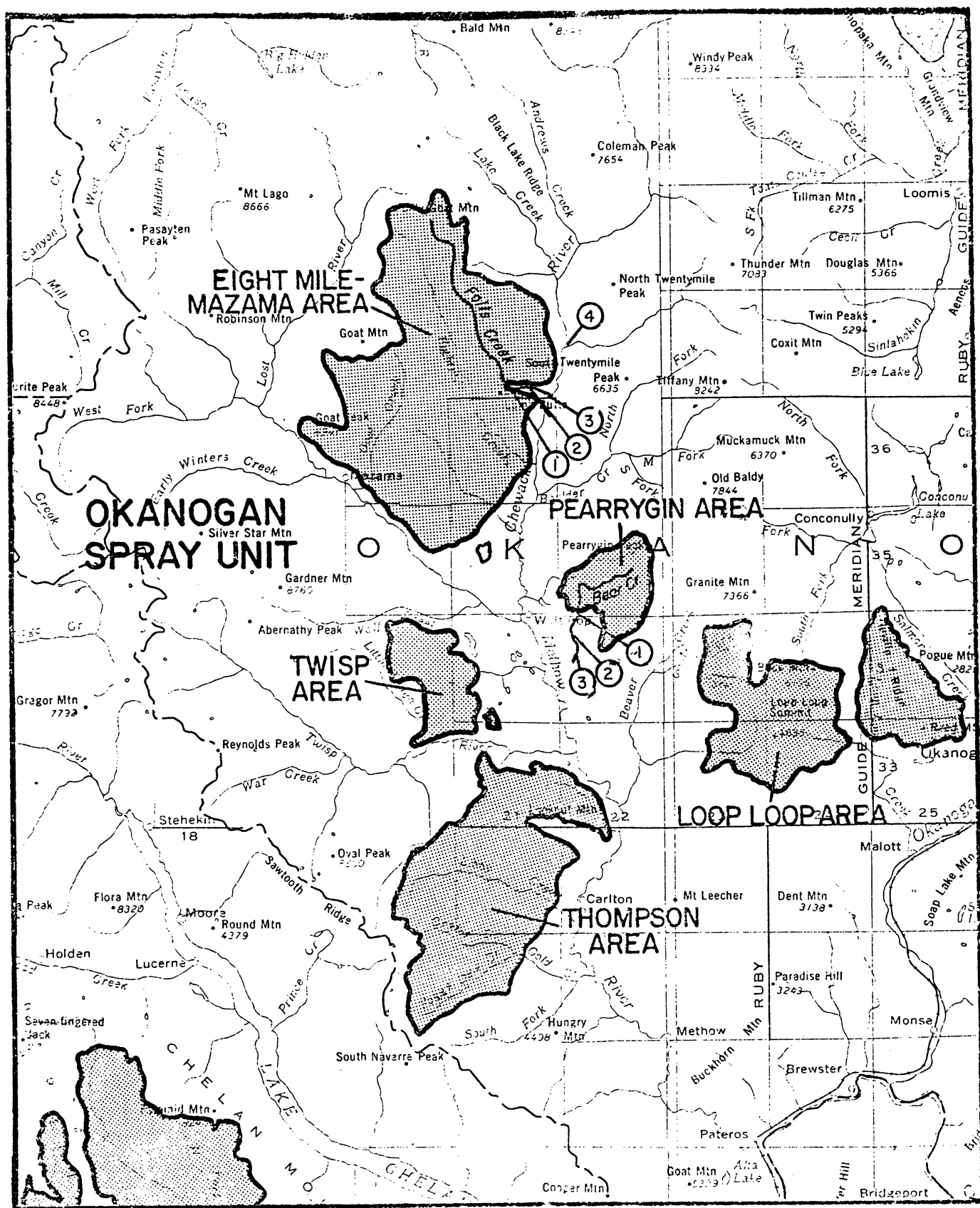


Figure 1. MAP SHOWING OKANOGAN SPRAY UNIT AND LOCATIONS OF STREAMS AND STATIONS WHERE DOE CONDUCTED AQUATIC MONITORING DURING 1977 WESTERN SPRUCE BUDWORM CONTROL PROJECT.

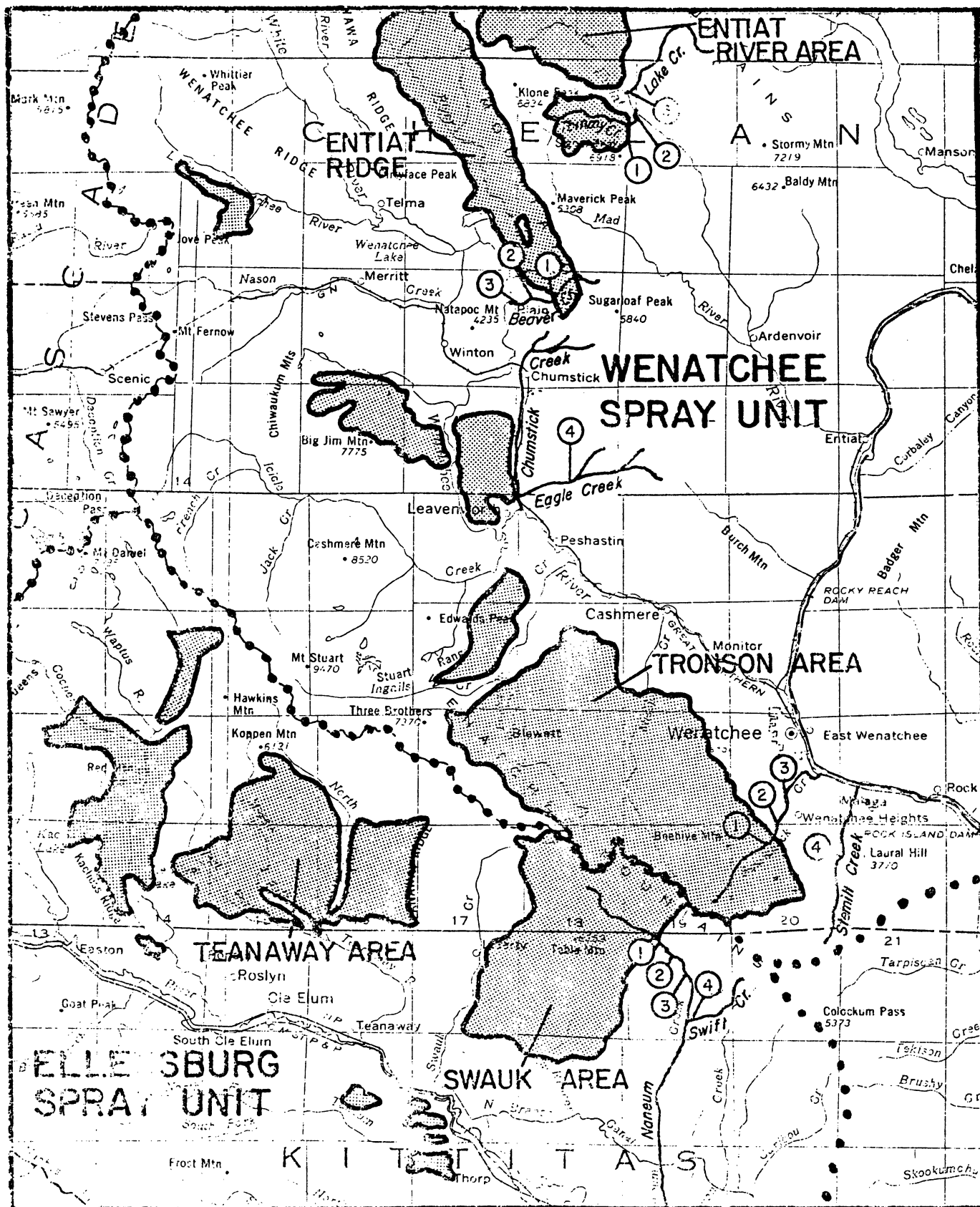


Figure 2. MAP SHOWING WENATCHEE AND ELLENSBURG SPRAY UNITS WITH LOCATIONS OF STREAMS AND STATIONS WHERE DOE CONDUCTED AQUATIC MONITORING DURING 1977 WESTERN SPRUCE BUDWORM CONTROL PROJECT.

FALLS CREEK EVALUATION

General Description

Falls Creek is located in the Eight Mile-Mazama Subunit of the Okanogan Spray area, about 10 miles north of Winthrop, Okanogan County (Figure 1). The creek measured about 20 feet wide, one foot deep, with a 20 cubic feet per second (cfs) flow during the spray project. Forests along both sides of the mainstem and headwaters were treated with Sevin-4-Oil on 28 June, 1977. Falls Creek was not buffered. The control station was located on the Chewack River.

Monitoring Results

Sevin appeared in Falls Creek water samples shortly after spraying commenced at 0500 and significant concentrations continued to show throughout sprayday (Figure 3). At station 1 an 18 ppb peak concentration was detected at 7.5 hours after spraying commenced, then the amount decreased to 7 ppb by +13 hours. Station 3 Sevin residues reached a peak of 29 ppb at +9.5 hours, then declined.

Figure 3. Comparison of Sevin concentrations (ppb) and drift insect counts in Falls Creek during sprayday, June 28, 1977.

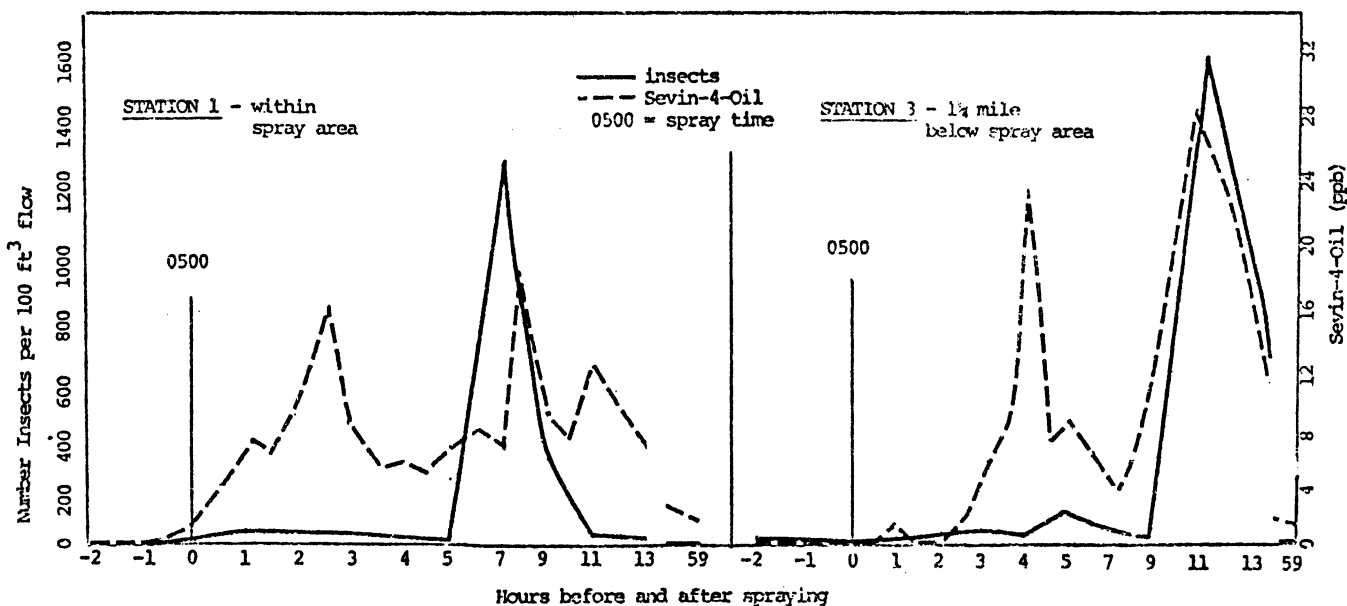


Figure 3 also shows that insect drift counts in Falls Creek increased significantly during sprayday. Station 1 counts reached a high of 1250 insects per 100 cubic feet of flow (cff) at +7 hours, then dropped sharply to 47 per 100 cff by +11 hours. Station 3 counts rose somewhat higher, to 1575 insects per 100 cff at +11 hours, then declined to 750 per 100 cff by +13 hours.

Additional spraying was done in the Falls Creek headwaters on 29 June 1977. Sevin concentrations at station 3 reached 11 ppb and insect counts 140 per 100 cff. Insect counts at both stations were near normal at +59 hours.

Diversity and abundance of benthic insect communities inhabiting Falls Creek were altered by the introduction of Sevin-4-Oil (Table 1). The station 1 postspray samples averaged about 1/3 as many insects per square foot as the prespray samples. Ephemeroptera accounted for nearly all of this reduction. Despite higher drift insect counts, total insect counts per square foot remained relatively stable. However, mayflies declined 50% at station 3.

Table 1. Comparison of pre- and postspray quantitative benthic insect samples collected from Falls Creek during Spruce Budworm Monitoring Study; DOE 1977

Sampling Run	Number of benthic insects per square foot					
	Ephemeroptera (may flies)	Diptera (true flies)	Trichoptera (caddis flies)	Plecoptera (stone flies)	Coleoptera (beetles)	Total
STATION 1						
4-day prespray	60	8	2	1	+	71
2-day postspray	11	11	2	1	0	25
STATION 3						
4-day prespray	16	8	2	1	0	27
2-day postspray	8	13	2	+	0	23

The station 1 livebox Ephemeroptera experienced a 55% mortality during sprayday while there were no Plecoptera or Trichoptera losses. No livebox insect mortalities occurred at stations 2, 3 or at the Chewack River Control. The livebox fish survived at all four stations.

Traces of Sevin were detected in one Falls Creek prespray water sample (Table 2). Concentrations reached 2.3 in the 2-day postspray samples. Sevin was not present in any other residue samples except for the benthic insects at station 1 where 121 ppb was detected in the 2-day postspray samples.

Table 2. Concentrations in ug/l of Sevin in samples of water, benthic insects, fish (livebox) and sediment collected from Falls Creek during Spruce Budworm Monitoring Study; DOE; 1977

Sampling Run	Water ^{1/}		Benthic Insects		Fish (Livebox)		Sediment	
	Sta. 1	Sta. 3	Sta. 1	Sta. 3	Sta. 1	Sta. 3	Sta. 1	Sta. 3
4-day prespray	0.1K, 0.1K	0.2, 0.1K	25K	25K	100K	100K	10K	10K
2-day postspray	2.0, 2.0 ^{2/}	2.3, 1.7	121	25K	100K	100K	10K	10K
34-day postspray	- -	0.1K ^{3/}	- -	25K	100K	- -	- -	10K

^{1/} Two samples were collected and analyzed.

^{2/} A 2-day postspray water sample collected at Station 2 contained 11.1 ppb residual Sevin

^{3/} K = less than

Comments

Although Falls Creek was classified buffered, significant amounts of Sevin reached the watercourse. The helicopter, observed spraying over Falls Creek above station 1, did not appear to follow correct buffering procedures on this stream.

BEAR CREEK EVALUATION

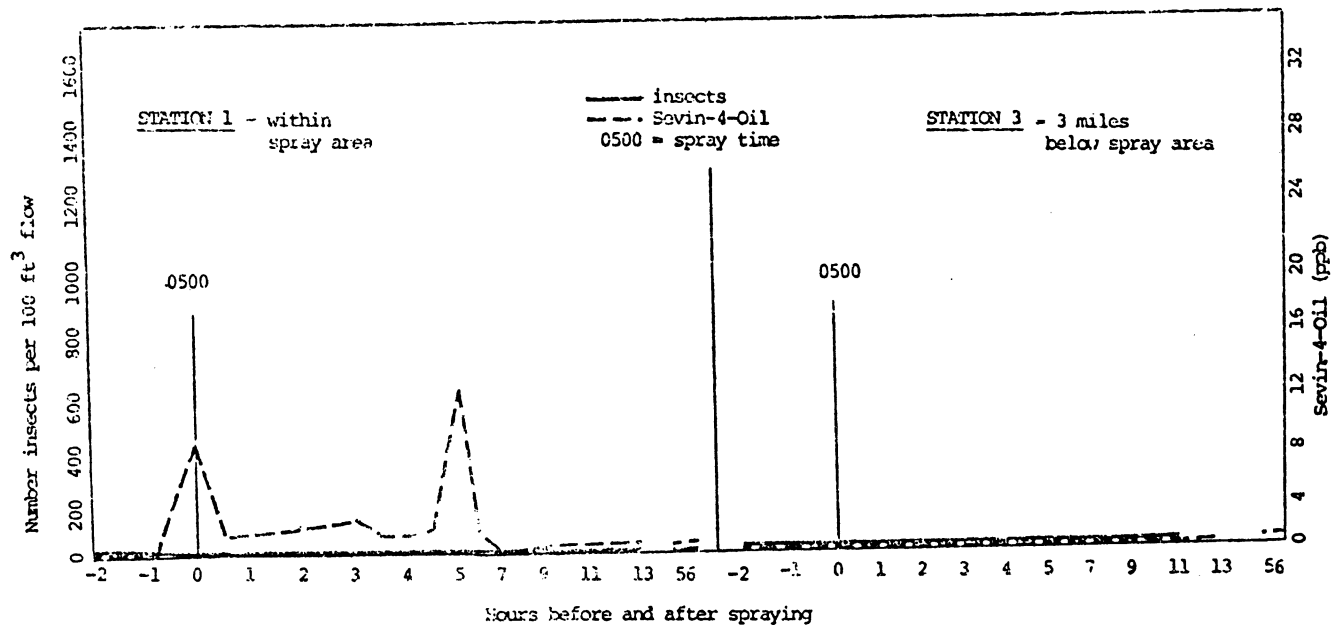
General Description

Bear Creek is a small stream located in the Okanogan National Forest about 3 miles east of Winthrop, Okanogan County (Figure 1). The creek lies in a narrow ravine with a dense canopy covering much of the stream. The creek was about 5 feet wide by less than one foot deep with a 0.5 cfs flow during the spray project. Forest lands, bordering about 3 miles of the mainstem and headwaters, were treated with Sevin-4-Oil on 2 July 1977. The creek was not buffered. The Chewack River served as the control.

Monitoring Results

Sevin appeared in Bear Creek water at station 1 shortly after spraying commenced at 0500 hours. A 13 ppb maximum concentration was detected at station 1 while insignificant concentrations were noted at station 3 (Figure 4). Figure 4 also shows that drift insect counts at both stations 1 and 3 remained at the prespray levels of about 5 insects per 100 cff.

Figure 4. Comparison of Sevin concentrations (ppb) and drift insect counts in Bear Creek during sprayday, July 2, 1977.



The insect communities remained relatively stable at stations 1 and 3 during the study period (Table 3). No mortalities were noted among the livebox fish and insects.

Table 3. Comparison of pre- and postspray quantitative benthic insect samples collected from Bear Creek during Spruce Budworm Monitoring Study; DOE 1977

Sampling Run	Number of benthic insects per square foot					Total
	Ephemeroptera (may flies)	Diptera (true flies)	Trichoptera (caddis flies)	Plecoptera (stone flies)	Coleoptera (beetles)	
STATION 1						
3-day prespray	16	60	4	2	0	82
2-day postspray	22	57	4	1	0	83
STATION 3						
3-day prespray	16	22	13	1	0	52
2-day postspray	24	26	14	3	5	72

Small amounts of Sevin were detected in the Bear Creek postspray water samples (Table 4). This probably occurred because a small section of the headwaters was treated several days prior to sprayday. Sevin concentrations appeared to increase in the 2-day postspray water sample. Some Sevin also was detected in the 2-day postspray benthic insect sample collected at station 1, where residues increased to 120 ppb. No Sevin was detected in any of the fish or stream sediment samples.

Table 4. Concentrations of residual Sevin (ppb) in samples of water, benthic insects, fish (livebox) and sediment collected from Bear Creek during Spruce Budworm Monitoring Study; DOE 1977

Sampling Run	Water		Benthic Insects		Fish (Livebox)		Sediment	
	Sta. 1	Sta. 3	Sta. 1	Sta. 3	Sta. 1	Sta. 3	Sta. 1	Sta. 3
3-day prespray	0.2	0.4	25K ^{1/}	25K	- -	- -	10K	10K
2-day postspray	- -	1.5	120	500K	100K	100K	10K	10K
30-day postspray	2/		2/	- -	2/	- -	10K	- -

^{1/} K = less than

^{2/} Bear Creek had dried up by the time this sampling run was conducted

Comments

Although Bear Creek was not buffered, Sevin did not appear to reach the stream in amounts great enough to measurably affect aquatic biota. The forest canopy and brush cover may have screened much of the stream from direct exposure to spray drift.

TOMMY CREEK EVALUATION

General Description

Tommy Creek is located in the Entiat Subunit of the Wenatchee spray area, Chelan County (Figure 2). The creek measured 16 to 20 feet wide by less than one foot deep with 30 cfs flow during the study period. Forests bordering the upper 4 miles of the stream were treated on 5 July, 1977. The stream was buffered. Because of the short distance between the Tommy Creek Spray Area's lower boundary and the creek's mouth at the Entiat River, only two sampling stations were established. Lake Creek served as the control.

Monitoring Results

Sevin residues were detected in Tommy Creek water samples during sprayday, with a 4.7 ppb peak concentration at +1.5 hours after spraying commenced. A 1.4 ppb maximum concentration was recorded at station 3 (Figure 5).

Figure 5. Comparison of Sevin concentrations (ppb) and drift insect counts in Tommy Creek during sprayday, July 5, 1977.

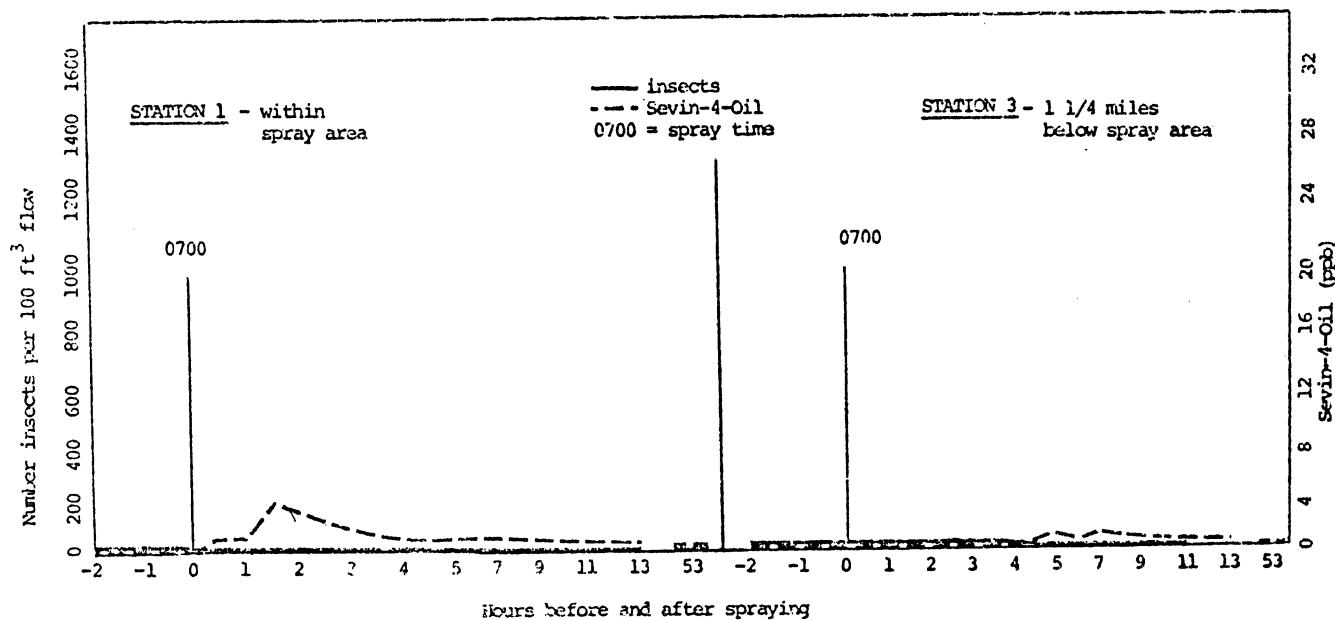


Figure 5 also indicates insect drift counts remained normal at stations 1 and 3. This correlated with the quantitative benthic insect sampling data, which indicated that the diversity and abundance of benthic insect communities remained stable during the sprayday (Table 5).

Table 5. Comparison of pre- and postspray quantitative benthic insect samples collected from Tommy Creek during Spruce Budworm Monitoring Study; DOE 1977

Sampling Run	Number of benthic insects per square foot					Total
	Ephemeroptera (may flies)	Diptera (true flies)	Trichoptera (caddis flies)	Plecoptera (stone flies)	Coleoptera (beetles)	
STATION 1						
13-day Prespray	61	5	7	+	1	74
3-day Postspray	71	3	3	+	0	77
STATION 3						
12-day Prespray	43	12	12	1	0	68
3-day Postspray	55	11	1	+	0	67

Additional, all Tommy Creek livebox fish and benthic insects survived during sprayday.

Concentrations of 240 and 170 ppb Sevin residues were noted in the Tommy Creek benthic insect prespray samples. No Sevin was detected in any of the postspray samples.

Comments

Aquatic biota in Tommy Creek did not appear to be adversely affected by the project. Water residues showed a small persistence two days after spraying. The high residue concentrations in the prespray insect samples were probably due to sample contamination, since all other residue data indicate Sevin-4-Oil did not accumulate in fish and insect tissues or the stream sediments.

BEAVER CREEK EVALUATION

General Description

Beaver Creek is located in the Entiat Ridge Subunit of the Wenatchee spray area, about 10 miles north of Leavenworth, Chelan County (Figure 2). The creek measured about 7 feet wide by several inches deep with a 2 cfs flow during the study period. Forests along the upper 2 miles of the stream were treated with Sevin-4-Oil on 29 June 1977. The watercourse was not buffered. Eagle Creek served as the Beaver Creek control.

Monitoring Results

Sevin residues were detected in the Beaver Creek water samples at station 1 shortly after spraying commenced. Concentrations reached 14 ppb at +1.5 hours then decreased to 1.2 ppb by +10 hours. Residues in station 3 water samples reached a high of 0.3 ppb (Figure 6).

Figure 6. Comparison of Sevin concentrations (ppb) and drift insect counts in Beaver Creek during sprayday, June 29, 1977.

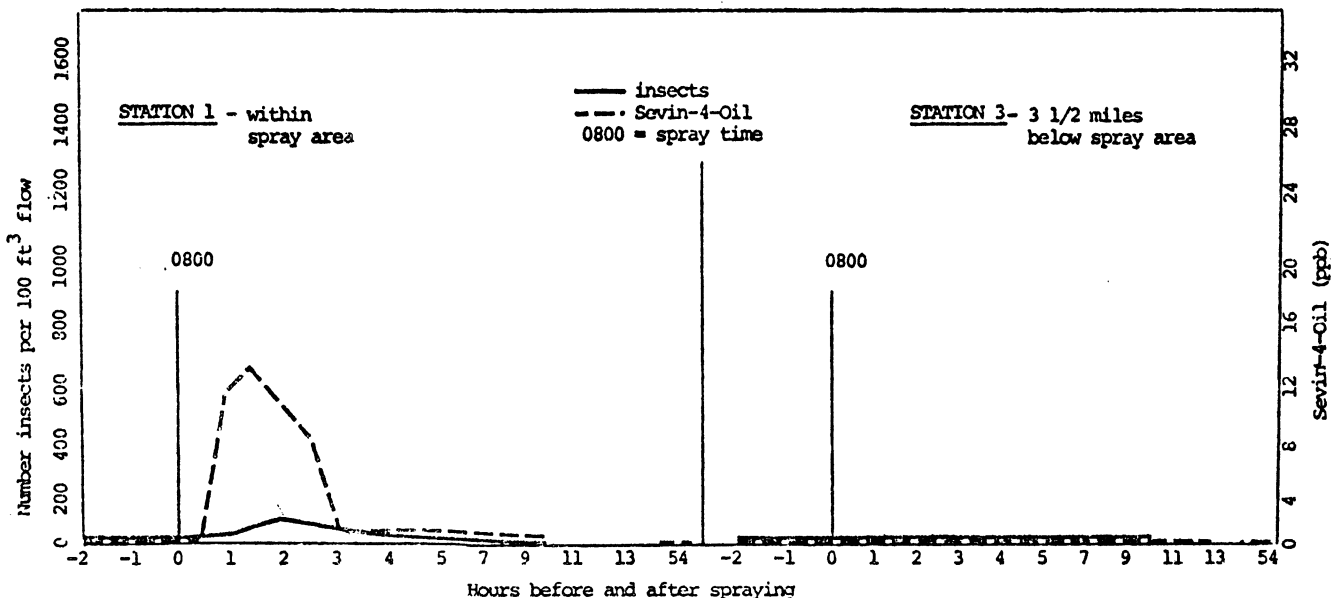


Figure 6 also shows that station 1 drift insect counts reached a peak of 125 insects per 100 cff at +2 hours, then slowly tapered off to prespray levels. Drift insect counts at station 3 did not exceed prespray levels,

Quantitative benthic insect data for station 3 were not included because a riffle area of uniform habitat could not be found. Most of the lower Beaver Creek had been heavily impacted by silt at some time

prior to summer 1977. The sampling results for station 1 are given in Table 6:

Table 6. Comparison of pre- and postspray quantitative benthic insect samples collected from Beaver Creek during Spruce Budworm Monitoring Study; DOE 1977

Sampling Run	Number of benthic insects per square foot					
	Ephemeroptera (may flies)	Diptera (true flies)	Trichoptera (caddis flies)	Plecoptera (stone flies)	Coleoptera (beetles)	Total
STATION 1						
12-day prespray	56	46	34	3	0	139
3-day postspray	66	27	26	1	1	121

These data further indicate the diversity and abundance of benthic insects inhabiting Beaver Creek may have been affected somewhat by the project, but a marked impact was not evident.

The livebox fish and insects experienced a 100% survival throughout sprayday at all stations on Beaver Creek and the Eagle Creek control.

Table 7 shows that Sevin was not detected in prespray water samples collected at stations 1 and 3. Small amounts of Sevin persisted in the stream waters 3 days after spraying while trace amounts appeared to be present 32 days after sprayday. No Sevin was detected in the benthic insect samples. However, some persistence was evident in the 3-day post-spray samples. Sevin was not detected in any of the fish (livebox) or sediment samples.

Table 7. Concentrations of residual Sevin (ppb.) in samples of water, benthic insects, fish (livebox) and sediments collected from Beaver Creek during Spruce Budworm Monitoring Study; DOE 1977

Sampling Run	Water		Benthic Insects		Fish (Livebox)		Sediment	
	Sta. 1	Sta. 3	Sta. 1	Sta. 3	Sta. 1	Sta. 3	Sta. 1	Sta. 3
Prespray	0.1K/0.1K ^{1/}	0.1K ^{2/} /0.1K	25K	25K	100K	100K	10K	10K
3-day postspray	.49/.48	0.1K/0.1K	76	69	100K	100K	10K	10K
32-day postspray	.10	--	25K	--	--	--	10K	--

^{1/} Two samples were collected

^{2/} K = less than

Comments

Although Beaver Creek was not buffered, the watercourse did not appear to be adversely affected by the spray project. A moderate increase in drift insect activity did occur during sprayday. The fact that in some areas the stream was protected from spraydrift by vegetation and trees growing along the stream margin may have been a contributing factor.

SQUILCHUCK CREEK EVALUATION

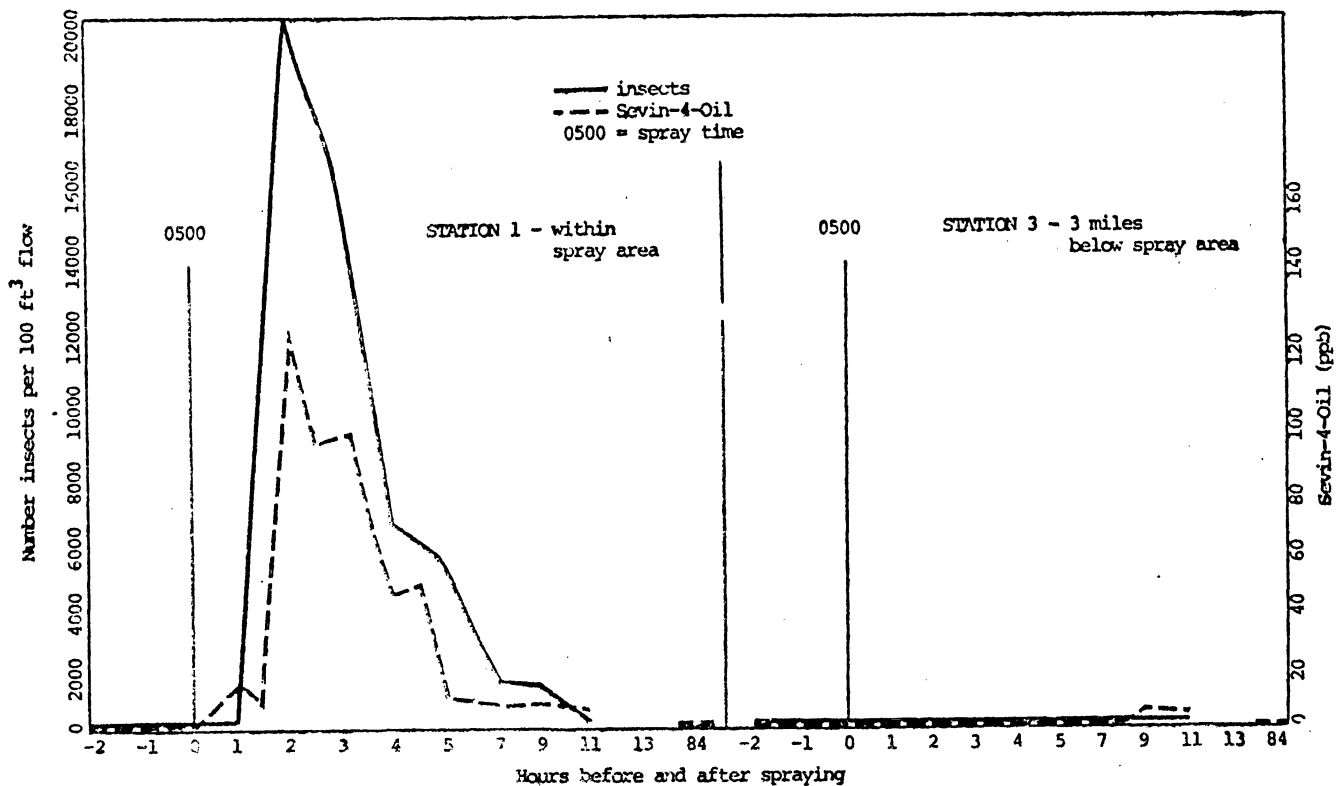
General Description

Squilchuck is a small creek located in the Tronson Subunit of the Wenatchee spray area (Figure 2). The gradient of Squilchuck Creek is fairly steep in the upper reaches, but the lower creek levels out, reducing flow velocity. The creek measured 3 to 5 feet wide by less than 0.5 foot deep with a 2 cfs flow during the study period. Sevin-4-Oil was applied to the Squilchuck headwaters and upper 2 miles of the mainstem on 3 July 1977. The stream was not buffered. Stemilt Creek served as the Squilchuck control.

Monitoring Results

Sevin appeared in Squilchuck waters at station 1 shortly after spraying commenced. A 121 ppb peak concentration was detected 2 hours later, then the amount declined to 14 ppb over the next 12-hour period. Small amounts of Sevin (5 ppb maximum) were detected at station 3 during sprayday (Figure 7).

Figure 7. Comparison of Sevin concentrations (ppb) and drift insect counts in Squilchuck Creek during sprayday, July 3, 1977.



At station 1 the drift insect counts increased from the prespray levels of 2 insects per 100 cff to about 20,000 insects shortly after spraying commenced (Figure 7). The counts dropped sharply to 571 insects per 100 cfs by the end of sprayday. Although not discernable on the graph, there was a slight increase in drift at station 3, where drift counts remained at about 1 insect per 100 cff except for slight increases to 6 and 25 insects per 100 cff during the +8 and +14 hours drifts. The 84-hour postspray drifts for station 1 contained about 1 insect per 100 cff.

When the pre- and post-spray quantitative benthic sampling data were compared, there was an 89% decrease in benthic insects per square foot at station 1 after sprayday, with all of the insect Orders declining in numbers (Table 8). Ephemeroptera and Plecoptera were the most severely impacted. Benthic insect communities did not appear to be affected at station 3.

Table 8. Comparison of pre- and postspray quantitative benthic insect samples collected from Squilchuck Creek during Spruce Budworm Monitoring Study; DOE 1977

Number of benthic insects per square foot						
Sampling Run	Ephemeroptera (may flies)	Diptera (true flies)	Trichoptera (caddis flies)	Plecoptera (stone flies)	Coleoptera (beetles)	Total
STATION 1						
13-day Prespray	150	58	33	8	0	249
3-day Postspray	4	14	10	>1	0	28
STATION 3						
12-day Prespray	>1	56	1	0	5	62
3-day Postspray	0	94	1	0	3	98

The station 1 livebox Plecoptera experienced a 95% stonefly mortality, although there were no mortalities in the Ephemeroptera or Trichoptera liveboxes nor did any fish mortalities occur. At station 2 there was a 90% Plecoptera mortality. No Ephemeroptera or Trichoptera mortalities occurred at this station. However, one-half of the 20 chinook salmon died in the fish livebox. There were no insect or fish mortalities in the liveboxes at station 3.

Prespray water samples collected at stations 1 and 3 did not contain detectable amounts of Sevin (Table 9). The 4-day postspray samples collected at these two stations contained a high of 1.26 ppb residual Sevin. Sevin residues were detected in the 30-day postspray samples and benthic invertebrates at stations 1 and 2 appeared to accumulate Sevin residues. The amount declined to pre-spray levels within 30 days. The same appeared to be true for the fish. Stream bottom sediments contained Sevin residues during each of the sampling runs.

Table 9. Concentrations of residual Sevin (ppb) in samples of water, benthic insects, fish (livebox) and sediment collected from Squilchuck Creek during Spruce Budworm Monitoring Study; DOE 1977

Sampling Run	Water		Benthic Insects		Fish (Livebox)		Sediment	
	Sta. 1	Sta. 3	Sta. 1	Sta. 3	Sta. 1	Sta. 3	Sta. 1	Sta. 3
Prespray	0.1, 0.1 ^{1/}	0.1, 0.1	25K	25K	100K	100K	32	6K
4-day postspray	1.02, 1.26	.79	101/120 ^{2/}	25K	131/152 ^{2/}	100K	10K	316
30-day postspray	.43		25K ^{3/}	--	100K	--	335	--

^{1/} Two samples were collected

^{2/} A station 2 sample

^{3/} K = less than

Comments

Application of Sevin to the Squilchuck Creek watershed appeared to have a significant adverse impact on aquatic biota inhabiting the stream. The Orders Ephemoptera were the most severely affected. The cause of the livebox fish mortalities at station 2 was not ascertained. Although 50% of the livebox fish at station 2 died, there were no mortalities upstream at station 1. Concentrations of Sevin in the creek did not appear to reach the lethal threshold. The established 96-hour LC₅₀ for coho salmon, brown trout, and rainbow trout are 764, 1950 and 4,380 ppb (Macek and McAllister, 1970). However, results from in situ studies such as the Squilchuck monitoring effort do not always parallel information from static bioassays conducted in controlled conditions.

NANEUM CREEK EVALUATION

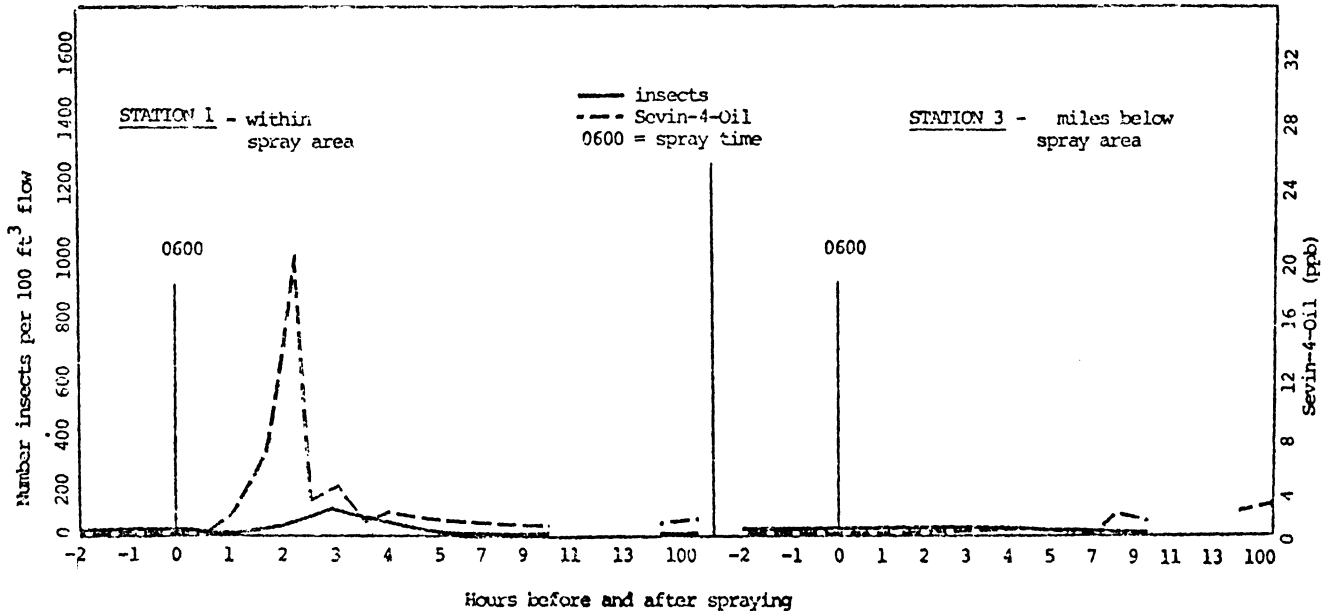
General Description

Naneum Creek is located in the Swauk Subunit of the Ellensburg spray area, about 17 miles north of Ellensburg, Kittitas County (Figure 2). The creek measured 10 to 15 feet wide by less than one foot deep with 20 cfs flow at the time of the study. Forests along the upper 3 miles of the mainstem and the headwaters were treated with Sevin-4-Oil on 5 July, 1977. The stream was buffered. Swift Creek served as the Naneum Creek control.

Monitoring Results

Sevin residues in the station 1 water samples increased to 20 ppb shortly after spraying commenced, then declined to 1.5 ppb during the next 13 hours (Figure 8).

Figure 8. Comparison of Sevin concentrations (ppb) and drift insect counts in Naneum Creek during sprayday, July 5, 1977.



Drift insect counts at station 1 increased from prespray levels to 75 insects per 100 cff at +3 hours, then returned to 3 insects per 100 cff by the end of sprayday (Figure 8). At station 3 insect drift counts remained at prespray levels throughout sprayday.

Benthic insect numbers declined somewhat at station 1 with mayflies the primary contributor to the decrease (Table 10). A similar decrease occurred at station 3. However the mayflies and caddisflies were the most severely affected.

Table 10. Comparison of pre- and postspray quantitative benthic insect samples collected from Naneum Creek, July 5, 1977.

Sampling Run	Number of benthic insects per square foot					Total
	Ephemeroptera (may flies)	Diptera (true flies)	Trichoptera (caddis flies)	Plecoptera (stone flies)	Coleoptera (beetles)	
STATION 1						
2-day Prespray	37	39	11	1	1	89
2-day Postspray	6	39	8	0	0	53
STATION 3						
2-day Prespray	69	27	58	1	+	155
2-day Postspray	50	27	26	1	0	104

Sevin residues of 0.18 ppb were found in the station 1 Naneum Creek prespray water samples. The 4-day postspray water samples collected at stations 1 and 3 contained 3.7 ppb Sevin while no Sevin was detected in the 30-day postspray samples. Sevin residues were not detected in the Naneum Creek prespray, 100-hour postspray, or 30-day postspray samples of water, benthic insects, fish or stream sediments.

Comments

The sprayday activities appeared to have a minimal adverse impact on aquatic biota inhabiting Naneum Creek. The fact that the spray craft was once observed spraying across the stream near station 1 may account for the concentration of Sevin reaching as high as it did during sprayday.

SUMMARY AND DISCUSSION

Six streams in Eastern Washington were monitored to evaluate impacts on the aquatic environment of Sevin-4-Oil applied to forest lands during the 1977 Spruce Budworm Control Project. Environmental impacts varied considerably from stream to stream. The project appeared to have an overall low-to-moderate impact on water quality and stream biota.

Tommy Creek was not affected other than the small amounts of Sevin (5 ppb maximum) detected in stream waters for several hours during sprayday. Bear Creek received moderate amounts of Sevin (14 ppb maximum) without a measurable impact on biota. About the same amount of Sevin (13 ppb maximum) was detected in Beaver Creek where adverse impacts were limited to a moderate increase in insect drift for several hours after spraying. Naneum Creek received slightly more Sevin (20 ppb maximum), causing a moderate increase in insect drift. Also, the diversity and abundance of benthic insect communities may have been altered.

Sevin concentrations in Falls Creek reached levels (29 ppb maximum) which increased insect drift activity and altered the diversity and abundance of benthic insect communities within the spray area and for a short distance downstream. Squilchuck Creek received the highest concentration of Sevin during sprayday (121 ppb) and the impacts appeared to be much greater. Insect drift counts increased markedly during sprayday and the diversity and abundance of benthic insect communities appeared to be altered for about 2 miles below the spray area, with Plecoptera the hardest hit. Some livebox fish mortality occurred at station 2.

The water quality and biological sampling data tend to support previous Sevin monitoring data collected by Tracy, et al (1976) that suggest benthic insect communities begin to respond when Sevin concentrations in the water course exceed about 10 ppb. The 1977 data further indicate that adverse impacts are minimal in the 10 to 20 ppb range but insect response increases considerably as concentrations move above about 25 ppb.

The three buffered streams may have been protected from spraydrift somewhat, however the monitoring results were masked because the spray craft dispersed Sevin-4-Oil over two of these streams (Falls Creek and Naneum Creek) near the lower spray boundary. The third buffered stream (Tommy Creek) where the spray craft appeared to leave a more than ample buffer strip along the mainstem, received the least amount of Sevin contamination of the six streams monitored.

A non-buffered stream (Squilchuck Creek) received the highest concentration of Sevin and experienced greater adverse environmental impacts than the other five study streams. However, the two remaining non-buffered streams (Beaver Creek and Bear Creek) experienced minimal impacts. The fact that these two small streams were located in areas of thick overgrowth and a fairly dense forest canopy may have been contributing factors.

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